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NOMOGRAPHIC COLUMN CHARTS

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NOMOGRAPHIC COLUMN CHARTS.

The charts collected in this report have been constructed at different times since April, 1920, but have never before been published in a shape convenient for the use of designers. Several similar charts are found on pages 299 to 303 of "Structural Analysis and Design of Airplanes," but they suffer from certain defects. The size is too small for practical use. Certain standard sizes of tubing are omitted and certain sizes now no longer standard are shown. In order to get the large tubes on the figure the lines representing the small tubes are confusingly close together. These faults are eliminated in the set of charts given in this report.

The method of using the charts is explained by the notes on them, especially the chart for small sizes of short columns of Specification 10225 steel. This chart can be recognized by the sloping line drawn across the chart and sloping upward to the right. The theory of their construction is given in Lipka's "Graphical and Mechanical Computation," Peddle's "The Construction of Graphical Charts," and d'Ocagne's "Traite' de Nomographie." By means of these charts it can be very quickly determined which one of a number of standard tubes should be used for a column when the compressive load, length, and

fixity of the ends are known. Their use also makes much more certain the employment of standard sizes of tubes.

The following charts are contained in this report:

1. Short columns (Parabolic formula range). Specification 10225. Carbon steel tubing. Small size tubes.
2. Short columns. Specification 10225. Tubing. Large size tubes.
3. Short columns. Specification 10227. Alloy steel tubing. Small size tubes.
4. Short columns. Specification 10227. Tubing. Large size tubes.
5. Long steel columns (Euler formula range). (Can also be used for long columns of duralumin.)
6. Long spruce columns.

Sometime in the future, when the sizes of duralumin tubing have been standardized and a value chosen for the yield point, charts for short duralumin columns will be added.

The charts for 10227 tubing are based on a yield point of 90,000 pounds per square inch and can be used only as a general guide for tubes in which the yield point has been raised by a special heat treatment.

CHART FOR CARBON STEEL, SPECIFICATION 10,225

$$P = \left[36,000 - \frac{36,000^2}{4C\pi^2 E} \left(\frac{L}{r} \right)^2 \right] A$$

For Pin Ends $C=1$

$$E = 28,000,000 \text{ #/sq in.}$$

For Fixed Ends $C=4$

Points are shown on this chart for $C=1$, $C=2$ and $C=3$. The three points for any one tube are connected by a solid line. Points for the same value of C are connected in order of sectional area, by dotted lines.

The table shows the maximum length for each tube, for which the chart is correct. For greater lengths the chart gives values below the allowable and Euler's Formula should be used $P = \frac{C\pi^2 EI}{L^2}$ the same values of C being used.

For tubes larger than $1\frac{3}{8}$ "-18g and up to $2\frac{3}{32}$ " see accompanying chart for Specification 10225

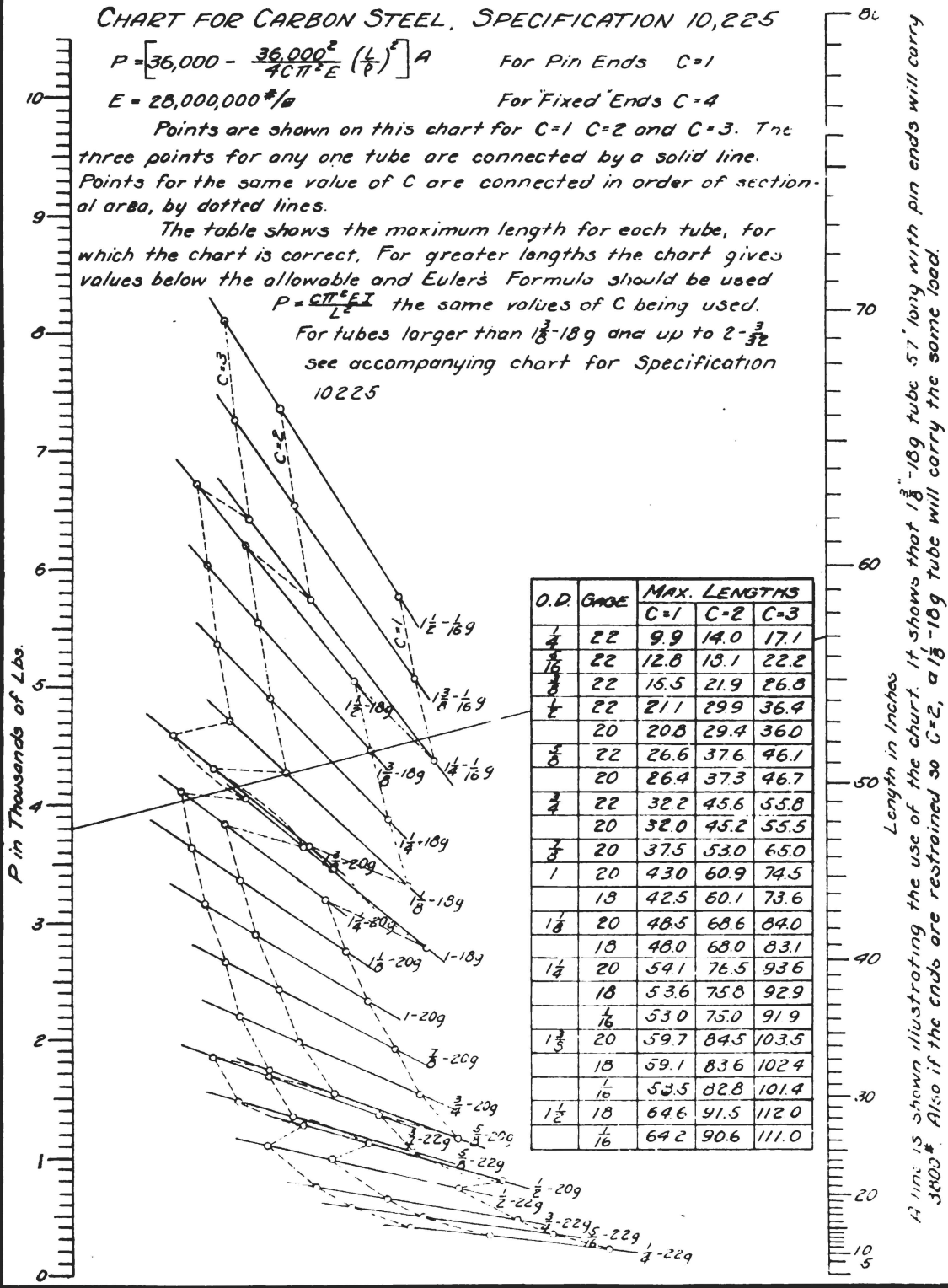


FIG. 1.

CHART FOR CARBON STEEL, SPECIFICATION 10,225

$$P = \left[36,000 - \frac{36,000^2}{4C\pi^2 E} \left(\frac{L}{\rho} \right)^2 \right] A$$

For Pin Ends $C=1$

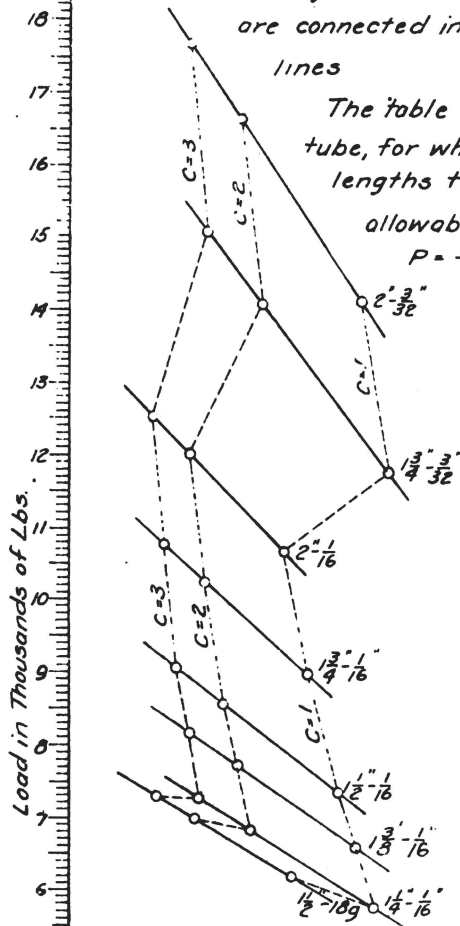
$$E = 28,000,000 \text{ #/sq in.}$$

For Fixed Ends $C=4$

Points are shown on this chart for $C=1$, $C=2$, and $C=3$. The three points for any one tube are connected by a solid line. Points for the same value of C are connected in order of sectional area, by dotted lines.

The table shows the maximum length for each tube, for which the chart is correct. For greater lengths the chart gives values below the allowable and Euler's Formula should be used

$$P = \frac{C\pi^2 EI}{L^2} \text{ the same values of } C \text{ being used}$$



O.D	Gage	Max Lengths		
		C=1	C=2	C=3
1 1/4	1/16	53.0	75.0	91.9
1 3/8	1/16	58.5	82.8	101.4
1 1/2	1/8	64.6	91.6	112.0
	1/16	64.2	90.6	111.0
1 3/4	1/16	75.2	106.3	130.1
	3/32	74.0	104.9	128.2
2	1/16	86.5	122.4	150.0
2	3/32	85.0	120.4	147.2

For tubes smaller than 1 3/4 - 1/16 and down to 1/4 - 22g, see accompanying chart for Specification 10225.

FIG. 2.

CHART FOR ALLOY STEEL TUBES, SPECIFICATION 10227

$$P = \left[90,000 - \frac{90,000^2 \left(\frac{L}{\pi} \right)^2}{4C\pi^2 E} \right] A \quad \text{For Pin Ends } C=1$$

$$E = 30,000,000 \text{ lbs per. sq. in.} \quad \text{For Fixed Ends } C=4$$

Points are shown on this chart for $C=1$, $C=2$, and $C=3$. The three points for any one tube are connected by a solid line. Points for the same value of C are connected, in order of sectional area, by dotted lines.

The table shows the maximum length for each tube, for which the chart is correct. For greater lengths the chart gives values below the allowable and Euler's Formula should be used $P = \frac{C\pi^2 EI}{L^2}$ the same values of C being used.

For tubes larger than $1\frac{3}{8}$ -18g and up to $2\frac{3}{4}$ -32, see accompanying chart for specification 10227.

O.D.	GRADE	MAX. LENGTHS		
		C=1	C=2	C=3
$\frac{3}{4}$	22	20.4	33.0	37.1
$\frac{7}{8}$	22	23.9	33.0	41.4
1	22	27.4	38.8	47.5
	20	27.2	38.6	47.1
	18	26.9	38.0	46.6
$1\frac{1}{8}$	20	30.8	43.6	53.4
	18	30.4	43.0	52.7
$1\frac{1}{4}$	20	34.2	48.4	59.3
	18	33.9	48.0	58.0
	$\frac{1}{2}$	33.6	47.5	58.3
$1\frac{3}{8}$	20	37.8	53.5	65.5
	18	37.5	53.0	65.0
$1\frac{1}{2}$	20	41.4	58.6	71.7
	18	41.0	58.0	71.0
	$\frac{1}{2}$	40.6	57.4	67.5
$1\frac{3}{4}$	20	48.5	68.5	84.0
	18	48.0	67.8	83.1
2	20	55.5	78.5	96.2

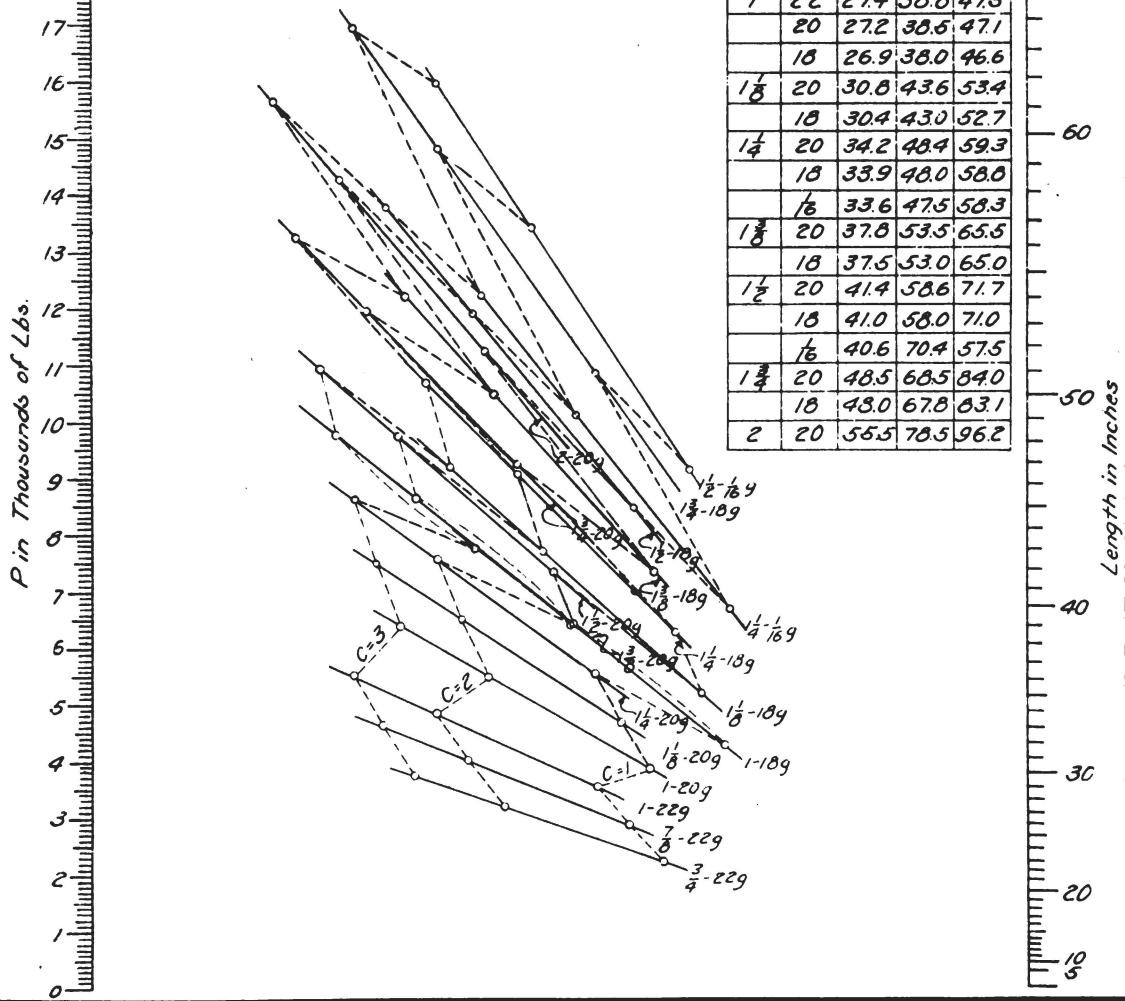


FIG. 3.

CHART FOR ALLOY STEEL TUBES, SPECIFICATION 10227

$$P = \left[90,000 - \frac{90,000^2}{4C\pi^2 E} \left(\frac{L}{r} \right)^2 \right] A \quad \text{For Pin Ends } C=1$$

$$E = 30,000,000 \text{ lbs. per sq. in.} \quad \text{For Fixed Ends } C=4$$

Points are shown on this chart for $C=1$, $C=2$, and $C=3$. The three points for any one tube are connected by a solid line. Points for the same value of C are connected, in order of sectional area, by dotted lines.

The table shows the maximum length for each tube, for which the chart is correct. For greater lengths the chart gives values below the allowable and Euler's Formula should be used. $P = \frac{C\pi^2 EI}{L^2}$ the same values of C being used.

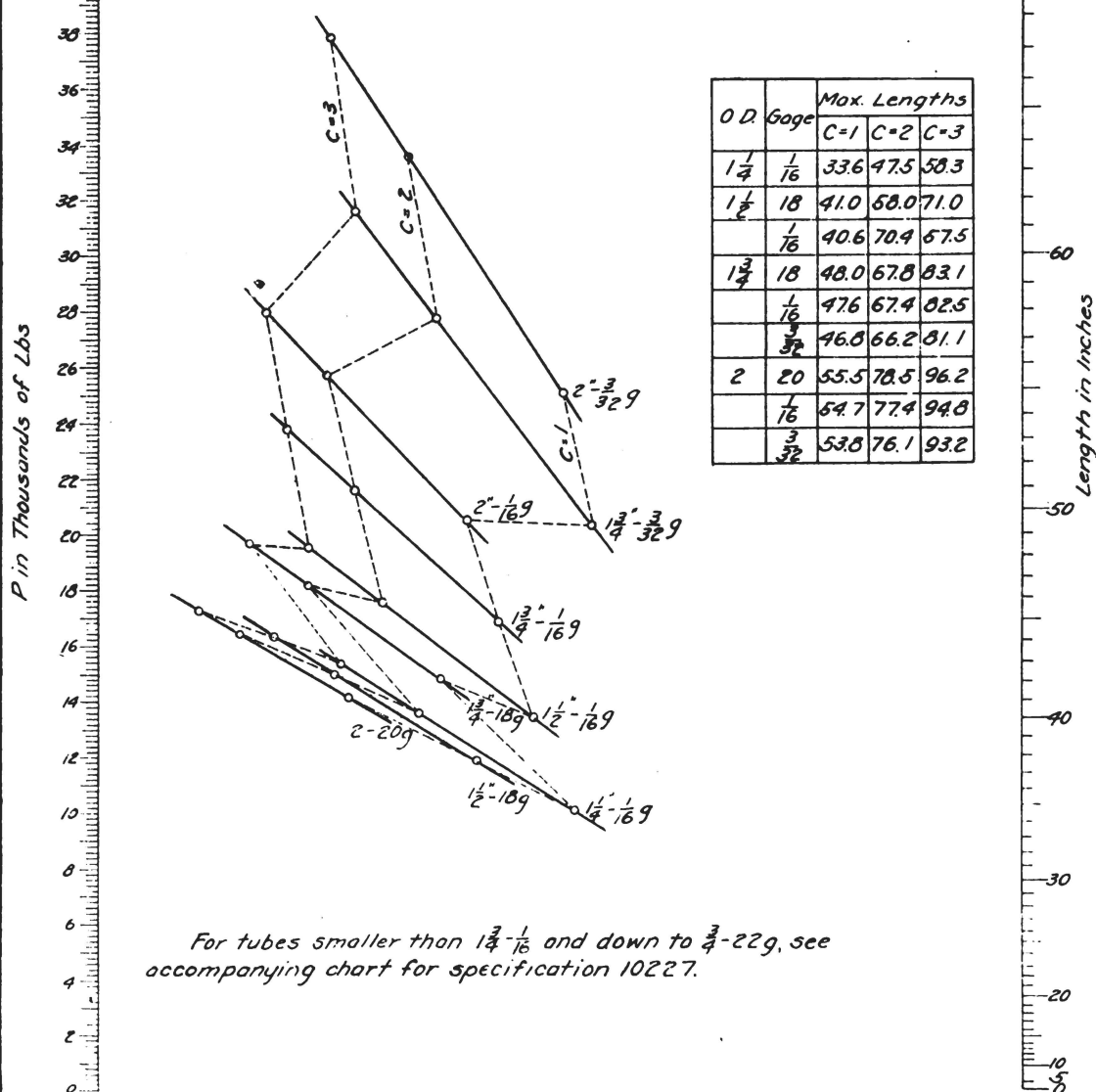
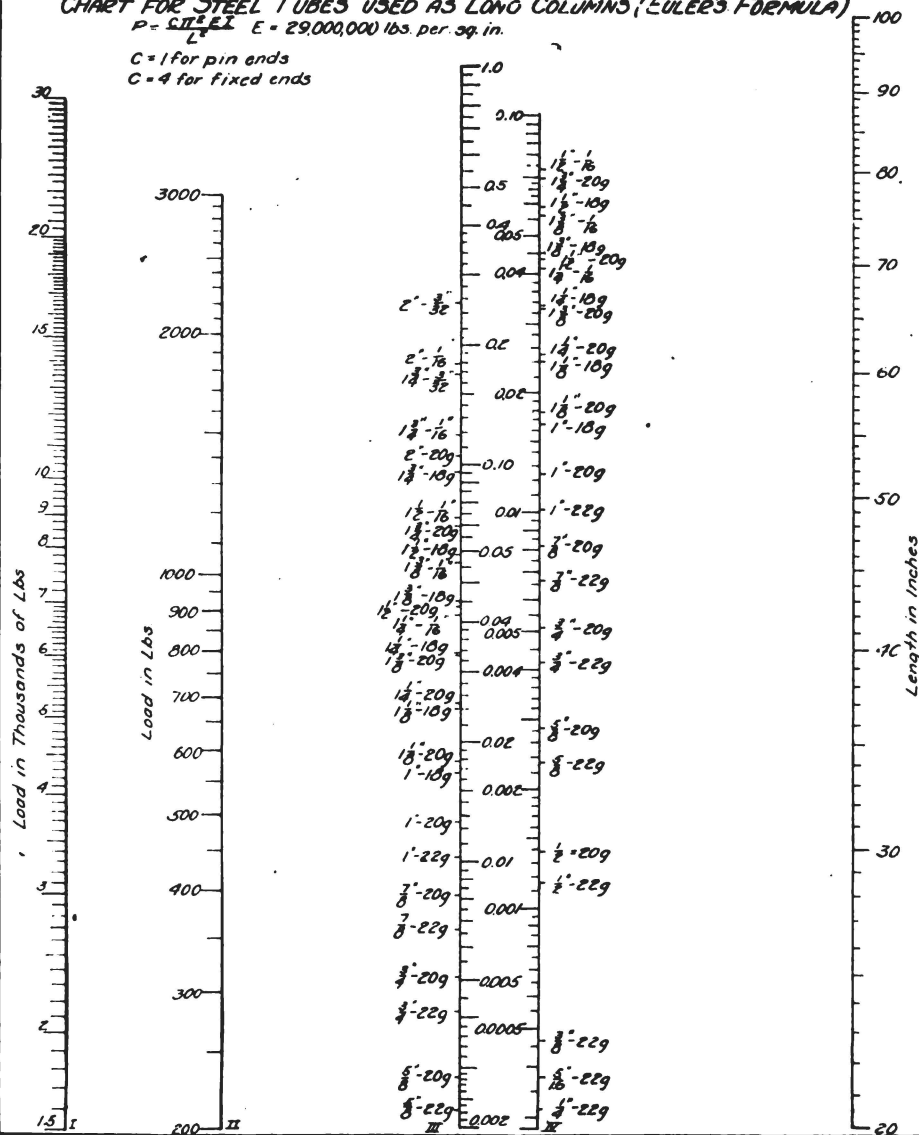


FIG. 4.

CHART FOR STEEL TUBES USED AS LONG COLUMNS (EULER'S FORMULA)

$$P = \frac{\pi^2 EI}{L^2} \quad E = 29,000,000 \text{ lbs. per sq. in.}$$

C = 1 for pin ends
C = 4 for fixed ends



This chart is plotted for C=1. When C>1 multiply the value of P given on the chart by C. Do Not Use This Chart when L is Less than the value given in the tables. In such cases use the charts for the parabolic formula $P = \left[\frac{1}{4} \frac{\pi^2 EI}{L^2} \right] \left[\frac{1}{4} \right]$. The sizes given in the tables are in order of weight. Use scale I with scale III or scale II with scale III. Scales III and IV are graduated on one side for Moments of Inertia, I.

Specification 10225				
O.D	Gage	C=1	C=2	C=3
1/4	22	99	14.0	17.1
3/16	22	12.8	18.1	22.2
3/8	22	15.5	21.9	26.8
1/2	22	21.1	29.9	36.4
5/8	20	20.8	29.4	36.0
3/4	22	26.6	37.6	46.1
7/8	22	32.2	45.6	55.8
1	20	26.4	37.3	46.7
1 1/8	20	32.0	45.2	55.3
1 1/4	20	37.5	53.0	65.0
1 3/8	20	43.0	60.9	74.5
1 1/2	20	48.5	68.6	84.0
1 3/4	20	54.1	76.5	93.6
1 7/8	13	42.5	60.1	73.6
2	20	59.7	84.3	103.3
2 1/8	18	48.0	68.0	83.1
2 1/4	18	53.6	75.8	92.9
2 3/8	18	59.1	83.6	102.4
2 1/2	18	64.6	91.5	112.0
2 5/8	14	53.0	75.0	91.9
2 3/4	14	58.5	82.2	101.4
2 7/8	14	64.2	90.6	111.0
3	14	75.2	106.3	130.1
3 1/8	14	86.5	122.4	150.0
3 1/4	14	97.0	138.9	170.2
3 1/2	2	85	120.4	147.2

Specification 10227				
O.D	Gage	C=1	C=2	C=3
3/4	22	20.4	33.0	37.1
1	22	23.9	38.8	41.4
1 1/8	22	27.4	44.6	47.5
1 1/4	20	27.2	44.5	47.1
1 3/8	20	30.8	49.6	53.4
1 1/2	20	34.2	54.4	59.3
1 5/8	18	26.9	38.0	46.6
1 3/4	20	37.8	53.5	65.5
1 7/8	20	41.4	58.6	71.7
2	18	30.4	43.0	52.7
2 1/8	18	33.9	48.0	58.8
2 1/4	20	40.5	60.5	74.0
2 3/8	18	37.5	53.0	65.0
2 1/2	20	55.5	78.5	96.2
2 5/8	18	41.0	58.0	71.0
2 3/4	14	33.6	47.5	58.3
2 7/8	18	48.0	67.8	83.1
3	14	40.6	58.4	71.5
3 1/8	14	47.6	67.4	82.5
3 1/4	14	54.7	77.4	94.8
3 1/2	14	66.2	91.1	111.0
3 3/4	2	33.8	47.1	58.2

This chart may be used for any steel strut whose $\frac{L}{r}$ is greater than that given below

Specification	C=1	C=2	C=3
10225	126	178	210
10227	790	113	130

This chart can be used for long Duralumin struts by dividing the value of P from the chart by 3 if $\frac{L}{r} > 88.6 \sqrt{C}$ when C=2 and 153 when C=3.

FIG. 5.

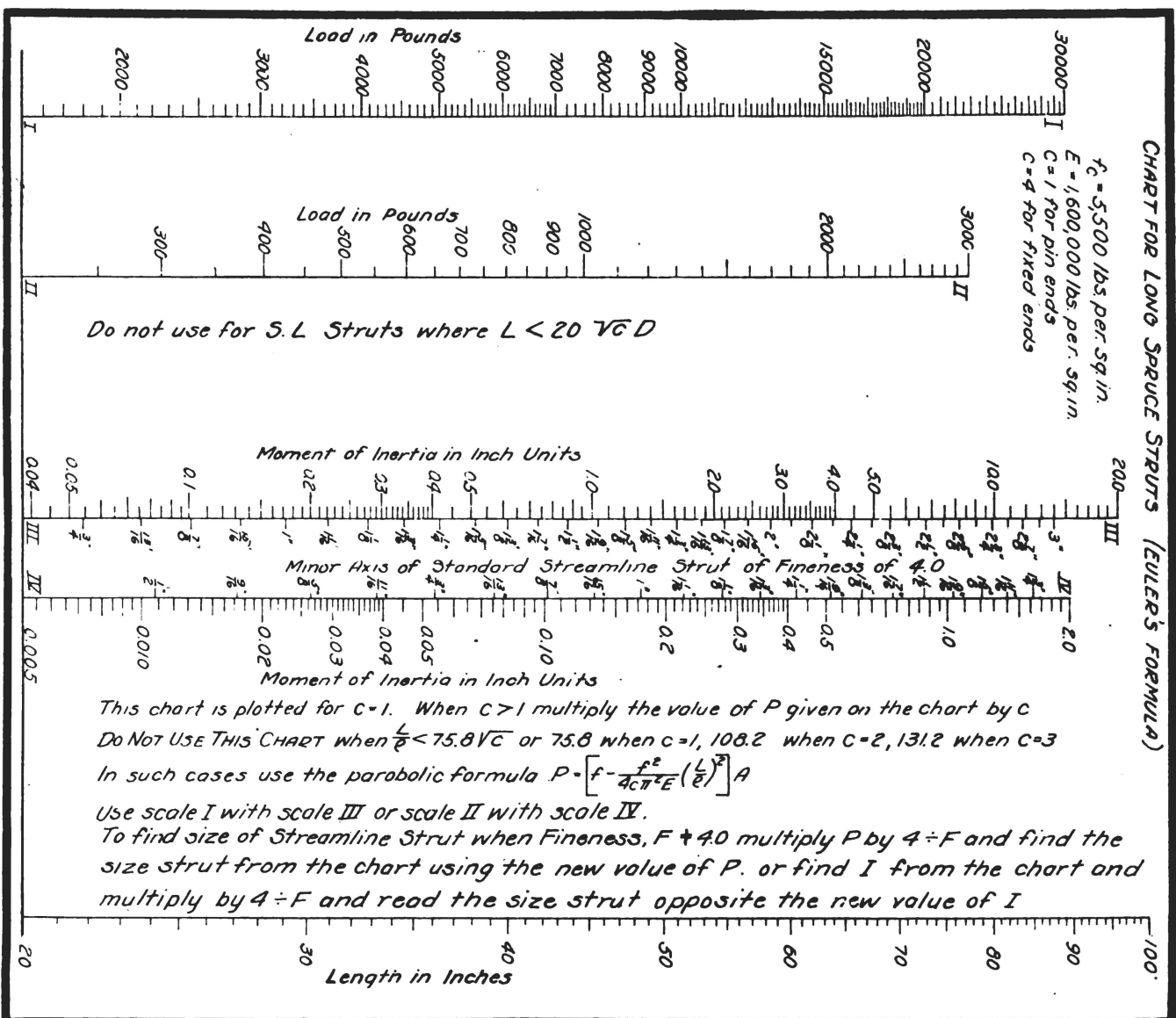


FIG. 6.